台灣昆蟲 27: 147-155 (2007)
Formosan Entomol. 27: 147-155 (2007)

賜諾殺濃餌劑誘殺東方果實蠅 (*Bactrocera dorsalise*) (雙翅目：果實蠅科) 之效果評估

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摘　要

在約 0.1 公頃周邊無阻隔的人心果果園內，施用賜諾殺 0.02%濃餌劑處理區誘得之東方果實蠅 (*Bactrocera dorsalis* (Hendel)) 雄蟲數顯著較少，約爲無施用對照區的 62.4%，調查期間最後 4 週之防治率達 72.7~86.4%，具明顯誘殺效果。在約與人心果果園同等面積的番石榴園施用賜諾殺餌劑，處理區調查期間最後 2 週之防治率僅爲 58.5~65.9%，可能是因處理區與無施用對照區相鄰無阻隔，致使對照區之蟲源亦會同時被誘除，但有施賜諾殺試區之果實被害率及被害度則皆顯著較無施用區爲低。另在面積約 1.7 公頃較大之椪柑園及其周邊 (約 0.3 公頃) 皆施用之情況下，施用賜諾殺餌劑處理區內果實之平均被害率爲 0，與無施用對照區有顯著差異。綜合此三種果園試驗結果，賜諾殺餌劑對東方果實蠅具明顯誘殺效果。當施用區較小時，可在周邊加強施藥或擴大施用面積，以阻殺可能侵入果園之外來蟲源，增強防治效果。

關鍵詞：賜諾殺餌劑、誘引劑、東方果實蠅、防治效果。

前　言

東方果實蠅 (*Bactrocera dorsalis* (Hendel)) 主要在台灣、中國及東南亞國家廣泛危害 (Fletcher, 1987)，造成柑桔、芒果、番石榴、人心果、楊桃等 30 多種重要經濟果樹的嚴重損失 (Liu and Hwang, 2000; Ho *et al*., 2004)。使用農藥防治害蟲所引起的抗藥性及殘毒污染問題，已受到學者專家及社會大眾普遍關注。因此不用農藥或選用比較安全的誘引劑已成爲東方果實蠅綜合管理之重要策略，其中包含誘引資材的開發應用及操作技術等研究 (Chu *et al*., 1996; Jang, 1997; Gazit *et al*., 1998; Chen *et al*., 2001)。

蛋白質水解物早在 1950 年代即被發現，配成毒餌能有效誘殺東方果實蠅 (Steiner, 1952)，至目前在台灣的「植物保護手冊」中仍然繼續推薦使用。新近引入的賜諾殺 0.02% 濃餌劑之殺蟲有效成分是一種較低毒的放線菌自然代謝產物，對人畜及環境較安全而適合

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應用在逐漸流行的有機農業上 (Thompson *et al*., 2000; Anonymous, 2001)。

在歐美、日本及中國等許多國家都已採用賜諾殺製劑，作爲玉米、蔬菜及瓜果等多種作物的防治藥劑，以誘殺玉米螟、小菜蛾及瓜果實蠅等多種害蟲 (Salgado, 1998)。目前在台灣賜諾殺餌劑已使用在番石榴東方果實蠅及入侵紅火蟻之防治上，而在柑桔園對東方果實蠅之測試亦具良好誘殺效果 (Ho *et al*., 2005; Ho *et al*., 2006)。

不同作物、栽培面積及周邊環境等對東方果實蠅之誘殺效果皆會產生影響 (Lin *et al*., 2006)，在本試驗中將進一步比較不同作物、不同面積及不同環境之誘殺效果，以作爲賜諾殺餌劑應用在有機栽培上防治東方果實蠅之潛力評估。

材料與方法

一、人心果果園誘殺試驗

將位於農業試驗所嘉義分所約 0.1 公頃周邊無阻隔但有楊桃、番荔枝及蓮霧等零星寄主分布之人心果 (*Manilkara zapota* (L.) Van Royen) 果園，區分爲處理區及對照區，各再分爲 2 重複小區。自 2006 年 4 月開始施用 0.02%賜諾殺濃餌劑 (台灣道禮公司進口，Dow AgroSciences LLC 製造，稀釋 8 倍，以 2 公升手提小噴筒，每株噴 4 大點，每大點約 5 ml) ，每週施用 1 次，共連續 8 週。每小區中各懸掛一組番石榴網袋包 (在 32 目紗網袋內置約 200 g 成熟番石榴，外罩 22 × 22 cm 黃色方形粘紙) 以誘引偵測雌蟲，另在施用處理區及無施對照區各懸掛一只渦旋式誘蠅器 (®安啦，台灣瑞芳公司出品，內置甲基丁香油誘殺板) 以偵測雄蟲。每週更換果實網袋包之粘紙及果餌，並在當天施用之前調查粘紙上之雌蟲數及誘蠅器內之雄蟲數。每週同時在每小區逢機調查 50 個近成熟人心果果實上之東方果實蠅產卵孔數 (將每果上之產卵孔數區分爲 1、2、3、4、5 及 6 孔以上等 6 級) ，再依此求算被害率、被害度及防治率。

二、番石榴果園誘殺試驗

在嘉義分所約 0.1 公頃無阻隔但周邊有楊桃、柑桔及印度棗等寄主植物之番石榴 (*Psidium guajava* L.) 果園，分爲處理區與對照區，各分爲 2 重複小區，自 2006 年 8 月開始施用賜諾殺餌劑 (如前)，每週施用 1 次，共連續 8 週。在各小區懸掛番石榴網袋包 (如前) 一組，每週更換果餌及粘紙，並計算粘紙上誘到之雌、雄蟲數。每週在每重複小區各調查 50 個近成熟番石榴果實之東方果實蠅產卵孔數 (每果之產卵孔數亦分成 6 級)，並求算被害率、被害度及防治率。

三、椪柑果園誘殺試驗

在嘉義竹崎選定面積約 1.7 公頃的椪柑 (*Citrus reticulate* Blanco) 果園及其周邊約 0.3 公頃含少許香蕉、龍眼及葡萄柚等其他寄主的試區，於 2006 年 9~12 月間全區施用賜諾殺餌劑 (如前)，每週施 1 次，共進行 16 週。在施用試區內及外圍無施用對照區各選定三處調查點 (各相距 30 m 以上)，各懸掛一組番石榴網袋包 (如前)。從第 9 週開始連續 8 週，每週調查粘紙上所誘得的東方果實蠅雌、雄蟲數，同時亦調查各調查點附近 50 個近成熟椪柑果實之產卵孔數，並依此求算被害率及被害度。

四、統計分析

先將蟲數以 $\sqrt{x+0.1}$ 轉換，百分率以 $\sin^{-1}$ 轉角，再以鄧肯氏多變域分析法比較各處

表一　賜諾殺餌劑在農業試驗所嘉義分所人心果果園誘殺東方果實蠅之效果

Table 1. The effectiveness of attracting the Oriental fruit fly with the use of Spinosad bait in a sapodilla orchard at Chiayi Station, ARI

Time of Investigation [1]	Females captured by sticky paper (Mean ± SD, n=2)		Males captured by Victor trap	
	Spinosad bait	No bait CK	Spinosad bait	No bait CK
Week 1	18.0 ± 4.2	22.5 ± 9.2	1063	1759
Week 2	8.5 ± 3.5	7.0 ± 5.7	612	907
Week 3	8.0 ± 4.2	6.0 ± 1.4	515	859
Week 4	8.5 ± 2.1	9.0 ± 2.8	861	1352
Week 5	7.0 ± 2.8	17.0 ± 5.7	1594	2538
Week 6	9.5 ± 2.1	5.5 ± 3.5	2044	3511
Week 7	3.5 ± 3.5	6.5 ± 0.7	1661	2655
Week 8	2.5 ± 0.7	5.5 ± 0.7	396	447
Average [2]	8.2 a	9.9 a	1093 B	1753 A

[1] April-May 2006.

[2] Means in the row followed by the same letter are not significantly different at 5% level by DMRT.

理平均值 5% 顯著水準下之差異顯著性 (Ho *et al.* 2005)。

$$被害率(\%) = 被害果數/調查果數 \times 100$$

$$被害度(\%) = \frac{\Sigma(被害等級 \times 該等級被害果數)}{6 \times 調查果數} \times 100$$

$$防治率(\%) = (1-\frac{處理區施藥後被害度 \times 對照區處理前被害度}{處理區施藥前被害度 \times 對照區處理後被害度}) \times 100$$

結　　果

一、人心果果園誘殺效果

連續8週在賜諾殺餌劑施用區果實網袋包所誘到之平均雌蟲數比在無施用對照區誘到者略少 (約為 82.8%，表一)，統計上無顯著差異，但整個試區之雌蟲數於以餌劑誘殺後則有降低之趨勢。另由渦旋式誘蠅器所誘得之平均雄蟲數，賜諾殺施用區則僅為無施對照區之 62.4%，兩者有顯著差異 ($p < 0.05$)。

賜諾殺餌劑處理區人心果平均被害率與被害度分別為 51.5 及 18.5%，有施用處理區與無施用對照區兩者間統計上之差異皆不顯著 (表二)。但被害率從第 1 週至第 8 週在賜諾殺施用區有略減之趨勢 (46%→38%)，而在對照區則明顯逐漸增加 (24%→66%)。同樣由被害度看更能顯現無施用對照區之增加趨勢 (6.2%→41%)，而在處理區則無此現象。由防治率顯示施用前 3 週之效果尚不明顯，但施用 8 週後之平均防治率達 52.2%，在調查期間最後 4 週，更維持在 72.7~86.4% 之間。

二、番石榴果園誘殺效果

在番石榴園賜諾殺餌劑處理區與無施用對照區網袋包粘紙上之平均誘到雌、雄蟲數均無顯著差異 (表三)，兩區皆在第 6 週時誘得最多之雌、雄蟲。然於賜諾殺處理區之雌、雄蟲數在第 8 週時顯著比第 1 週時為少，但在無施用對照區則無此較少現象。在表四中賜諾殺餌劑處理區之平均番石榴果實被害率及被害度，皆較無施用對照區者顯著為低 ($p < 0.05$)。又可見從試驗開始 (第 0 週) 至最後 (第 8 週)，在處理區之被害率及被害度分別從

表二　嘉義分所人心果試區東方果實蠅之為害與防治效果調查

Table 2. The damage rates and control efficacy of the Oriental fruit fly in a sapodilla orchard at Chiayi Station

Time of Investigation[1)]	Fruit damage (%)		Degree of fruit infested (%)		Control rate (%)
	Spinosad bait	No bait CK	Spinosad bait	No bait CK	
Week 0	46.0 ± 14.1	24.0 ± 8.5	13.0 ± 1.0	6.2 ± 0.7	--
Week 1	61.0 ± 26.9	30.0 ± 5.7	17.7 ± 5.7	10.3 ± 2.9	18.0
Week 2	63.0 ± 29.7	29.0 ± 10.0	25.0 ± 16.5	11.3 ± 4.9	0.0
Week 3	58.0 ± 22.6	37.2 ± 12.5	21.9 ± 9.7	12.9 ± 4.9	19.0
Week 4	58.0 ± 5.7	54.7 ± 3.8	22.2 ± 6.9	24.4 ± 2.3	56.6
Week 5	48.0 ± 8.5	67.2 ± 12.5	13.3 ± 2.8	32.6 ± 9.5	80.5
Week 6	48.0 ± 11.3	73.0 ± 9.9	22.7 ± 4.2	39.7 ± 7.6	72.7
Week 7	38.0 ± 17.0	73.0 ± 9.9	13.5 ± 6.4	40.9 ± 1.6	84.3
Week 8	38.0 ± 8.5	66.0 ± 14.1	11.7 ± 0.5	41.0 ± 3.3	86.4
Av (wk 1-8) [2)]	51.5 a	53.8 a	18.5 A	26.6 A	52.2

1) April-May 2006.

2) Means in the row followed by the same letter are not significantly different at 5% level by DMRT.

表三　賜諾殺餌劑在嘉義分所番石榴園誘殺東方果實蠅之效果

Table 3. The effectiveness of attracting the Oriental fruit fly with the use of Spinosad bait in a guava orchard at Chiayi Station

Time of Investigation[1)]	Sex	No. flies captured by sticky paper (Mean ± SD, n=2)	
		Spinosad bait	No bait CK
Week 1	♀	20.0 ± 9.9	17.5 ± 0.7
	♂	18.0 ± 12.7	13.0 ± 0.0
Week 2	♀	15.0 ± 1.4	9.5 ± 0.7
	♂	9.0 ± 0.0	13.5 ± 2.1
Week 3	♀	10.0 ± 5.7	14.5 ± 4.9
	♂	6.0 ± 4.2	3.0 ± 2.8
Week 4	♀	10.5 ± 10.6	8.0 ± 1.4
	♂	9.0 ± 8.5	9.0 ± 1.4
Week 5	♀	17.5 ± 3.5	13.0 ± 5.7
	♂	18.0 ± 5.7	18.0 ± 7.1
Week 6	♀	33.5 ± 7.8	35.0 ± 5.7
	♂	51.5 ± 9.2	47.0 ± 36.8
Week 7	♀	8.0 ± 2.8	9.0 ± 5.7
	♂	9.0 ± 1.4	8.0 ± 5.7
Week 8	♀	8.0 ± 4.2	15.0 ± 5.7
	♂	2.0 ± 1.4	16.0 ± 7.1
Average [2)]	♀	15.3 a	15.3 a
	♂	13.8 A	15.9 A

1) Aug.-Oct. 2006.

2) Means in a row followed by the same letter are not significantly different at 5% level by DMRT.

68.0 及 62.5% 降至 47.1 及 22.2%，有較明顯的減少，而無施對照區之減少則不明顯。全期 8 週防治率之平均爲 32.5%，而最後兩週時之防治率則分別爲 65.9 及 58.5%。

表四　嘉義分所番石榴試區東方果實蠅之為害與防治效果調查

Table 4. The damage rates and control efficacy of the Oriental fruit fly in a guava orchard at Chiayi Station

Time of Investigation[1)]	Fruit damage (%)		Degree of fruit infested (%)		Control rate (%)
	Spinosad bait	No bait CK	Spinosad bait	No bait CK	
Week 0	68.0 ± 5.7	74.0 ± 14.1	62.5 ± 10.2	60.0 ± 23.3	--
Week 1	50.0 ± 2.9	63.0 ± 1.4	28.5 ± 6.8	37.0 ± 5.2	25.4
Week 2	48.0 ± 2.8	60.0 ± 2.8	26.2 ± 3.0	37.0 ± 3.3	31.5
Week 3	71.0 ± 26.9	67.0 ± 7.1	51.2 ± 37.7	51.7 ± 21.0	4.1
Week 4	65.0 ± 1.4	81.0 ± 12.7	40.0 ± 3.5	58.9 ± 21.4	33.4
Week 5	71.5 ± 19.1	86.5 ± 12.0	58.6 ± 31.5	71.9 ± 31.0	21.1
Week 6	42.8 ± 3.9	54.0 ± 5.6	29.4 ± 22.8	35.6 ± 31.5	20.0
Week 7	23.8 ± 17.8	48.9 ± 33.7	15.4 ± 6.1	43.7 ± 41.1	65.9
Week 8	41.7 ± 19.7	67.5 ± 10.6	22.2 ± 5.2	51.8 ± 19.1	58.5
Av (wk 1-8) [2)]	51.7 b	66.0 a	34.0 B	48.5 A	32.5

1) Aug.-Oct. 2006.

2) Means in the row followed by the same letter are not significantly different at 5% level by DMRT.

三、椪柑果園誘殺效果

竹崎椪柑園賜諾殺餌劑施用區每週所誘得之東方果實蠅雌、雄蟲平均不到 1 隻，且顯著較無施用對照區爲少（表五），處理區 8 週平均誘得之雌、雄蟲數僅約爲對照區之 5 分之 1，差異極爲顯著（$p < 0.05$）。在賜諾殺餌劑處理區之果實被害率與被害度則皆爲 0，而無施用對照區之被害率與被害度則平均分別爲 0.25 及 0.04%（表六），兩者在統計上亦有顯著差異。

討　　論

由表一人心果果園誘殺之雄蟲數可知，4~5 月間田間東方果實蠅之密度已非常高。因蟲源太多，試區不大而處理區又與對照區緊鄰無阻隔，造成處理區不斷會有蟲源流入而對照區之部分雌蟲亦會被賜諾殺餌劑所誘殺，使得兩者誘到之平均雌蟲數差異不顯著。然因甲基丁香油之誘雄量非常大，使得兩者在統計上能顯現出差異。又由表二對照區之被害率及被害度有明顯增加之趨勢，及最後高達 86.4% 之防治率，可見賜諾殺餌劑在人心果試區對東方果實蠅確有相當不錯的誘殺效果。另由處理區及對照區平均之被害率及被害度相互比較來看，因被害度是將被害程度細分爲 6 等級，故以被害度求得之防治率更能顯示出防治效果，此與 Ho *et al.* (2005) 之試驗結果類似。

在番石榴試區中施用賜諾殺餌劑之面積僅有 0.05 公頃，又與無施對照區緊鄰且無任何阻隔，致使兩區誘得之平均雌、雄數無明顯差異（表三），乃因在對照區中之蟲源亦同時會被鄰近之賜諾殺餌劑所誘殺。然有施用處理區每週每網袋包平均所誘到之 15.3 隻雌蟲及 13.8 隻雄蟲，若與往年在斗六番石榴園（Ho *et al.*, 2004）之無施用對照區每網袋包所誘得之 60 隻雌蟲及 50 隻雄蟲作爲參考基準相較，亦能看出本年度經賜諾殺餌劑誘殺後之東方果實蠅密度已明顯較少。因 8~10 月間在番石榴試區附近之果實蠅密度相當高，致使有施用處理試區之平均被害率及被害度分別高達 51.7 及 34.0%（表四），而防治率最高僅達 65.9%。然若與前述往年在斗六對照區之 100% 被害率及 96~97% 之被害度比較，賜諾殺餌劑

表五　賜諾殺餌劑在嘉義竹崎椪柑園誘殺東方果實蠅之效果

Table 5. The effectiveness of attracting the Oriental furit fly with the use of Spinosad bait in a ponkan orchard at Chuchi, Chiayi

Time of Investigation[1)]	Sex	No. flies captured by sticky paper (Mean ± SD, n=3)	
		Spinosad bait	No bait CK
Week 1	♀	1.0 ± 1.7	6.7 ± 2.5
	♂	0.0 ± 0.0	2.7 ± 3.8
Week 2	♀	0.0 ± 0.0	5.7 ± 2.1
	♂	0.0 ± 0.0	2.0 ± 1.0
Week 3	♀	0.7 ± 1.2	3.7 ± 3.8
	♂	0.3 ± 0.6	2.7 ± 1.5
Week 4	♀	2.0 ± 3.5	11.3 ± 4.0
	♂	0.0 ± 0.0	3.3 ± 1.2
Week 5	♀	2.0 ± 1.7	3.3 ± 3.2
	♂	1.7 ± 1.5	3.3 ± 1.5
Week 6	♀	0.7 ± 1.2	1.0 ± 1.0
	♂	0.0 ± 0.0	2.0 ± 3.5
Week 7	♀	0.3 ± 0.6	4.3 ± 2.3
	♂	0.3 ± 0.6	5.7 ± 6.7
Week 8	♀	0.7 ± 1.2	3.7 ± 4.7
	♂	3.3 ± 3.1	4.3 ± 1.5
Average [2)]	♀	0.9 b	4.9 a
	♂	0.7 B	3.3 A

1) Oct.-Dec. 2006.

2) Means in a row followed by the same letter are not significantly different at 5% level by DMRT.

表六　嘉義竹崎椪柑試區東方果實蠅之為害調查

Table 6. The damage rates of the Oriental fruit fly in a ponkan orchard at Chuchi, Chiayi

Time of Investigation [1)]	Fruit damage (%)		Degree of fruit infested (%)	
	Spinosad bait	No bait CK	Spinosad bait	No bait CK
Week 1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Week 2	0.0 ± 0.0	0.7 ± 1.2	0.0 ± 0.0	0.1 ± 0.2
Week 3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Week 4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Week 5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Week 6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Week 7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Week 8	0.0 ± 0.0	1.3 ± 2.3	0.0 ± 0.0	0.2 ± 0.4
Average [2)]	0.0 b	0.25 a	0.0 B	0.04 A

1) Oct.-Dec. 2006.

2) Means in the row followed by the same letter are not significantly different at 5% level by DMRT.

已在此小試區中呈現非常明顯的誘殺效果。

竹崎椪柑園賜諾殺餌劑施用區之面積含周邊區域達 2 公頃，如此構成一片完整且有阻隔的大試區。從果實被害之前（約 6~7 分熟）

即已開始施用，全期共施 16 次，能即時充分誘殺園區附近的東方果實蠅蟲源，致使鄰近無施用對照區所誘得之蟲數亦不高 (表五)。在誘殺後相對蟲源密度很低之情況下，致使施用處理區調查之果實完全沒有被害，而鄰近之對照區受害率亦極低 (表六)。然在同時期較遠處無賜諾殺餌劑處理之椪柑果實被害率，據農民估計約為 2~5%。又因為第 9 週開始調查之前，在處理區與對照區之被害度皆為 0，故無法依此來求算防治率。再與年前 (Ho *et al.*, 2006) 在彰化溪州 1 公頃柑桔園試驗區之誘殺結果 (0.05% 的被害率) 相較，在本試驗中賜諾殺之誘殺效果更為明顯。

綜上諸區的試驗結果確可顯示，賜諾殺餌劑在大面積椪柑園之防治效果較在小面積之人心果與番石榴園為佳。當賜諾殺施用區較小時，只要在其周邊加強施用或擴大防治面積，即可阻殺外來侵入之果實蠅蟲源，進而增進誘殺效果。因為人心果與番石榴試區之周邊有不少之寄主存在，致使防治效果亦會降低，在 Lin *et al.* (2006) 之報導中，亦證實周緣的非經濟寄主對東方果實蠅之棲息及繁殖會有很大的影響。另基於賜諾殺餌劑之有效性及無殘留毒 (Thompson *et al.*, 2000)，對自然環境及施用人員較安全，而點噴法又方便操作，故未來在有機果園防治東方果實蠅上頗有被廣泛應用之潛力。

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收件日期：2007 年 4 月 11 日
接受日期：2007 年 5 月 27 日

Attracting Effectiveness of Spinosad Bait in Killing the Oriental Fruit Fly, *Bactrocera dorsalis* (Diptera: Tephritidae)

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ABSTRACT

The number of male oriental fruit fly from the 0.02% spinosad bait-treated plot (with 8-fold dilution rate) in an open sapodilla orchard (ca 0.1 ha) without barrier was significantly less, 62.4% comparing to the check plot. The control rates of the last 4 weeks were 72.7-86.4% which indicated a significant attracting and killing effect with the use of spinosad bait. spinosad bait was also applied in a small guava orchard, about the same size as the sapodilla orchard, and the control rate calculated from the last 2 weeks were only 58.5-65.9%. The low control rates might be due to that the treated and check plots were too close and no blockade so that the population in check plot was trapped simultaneously. However, the percentage of fruit damage and the degree of fruit infested were significantly lower in the spinosad bait-treated plot than in the non-used check plot. Also, spinosad bait was used in a larger ponkan orchard (ca 1.7 ha) and its surrounding area (0.3 ha), the average percentage of fruit damage was 0 in the spinosad bait-treated plot that was significantly different from that in the control plot. Summarized from the results of three tests, the spinosad bait had a significant control efficacy for the oriental fruit fly. As the application orchard is small, we can add more sprays on the surrounding area or expand the treated area to trap for the outside fly population which may intrude into the orchard, to ensure a better control.

Key words: spinosad bait, attractant, *Bactrocera dorsalis*, control efficacy

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